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(54) APPARATUS AND PROCESS FOR MOLDING OF HOLLOW ARTICLES

(71) We, INTERNATIONAL PAPER COMPANY, a corporation organised under the laws of the State of New York, United States of America, of 220 East 42nd Street, New York, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

BACKGROUND OF THE INVENTION

This invention relates to a molding process and apparatus for producing hollow articles. In the past, hollow articles have been produced by a variety of dipping, molding and extrusion apparatus and processes. However, each of these prior art processes and apparatus have suffered from disadvantages that are substantially overcome by the present apparatus and process.

In the dipping processes known in the prior art, a wire core is dipped into a liquified material to be formed into the hollow article. With each dip of the wire more product from the bath adheres to the coated wire until eventually the desired amount of material is built up onto the wire. Then the material coated on the wire is sufficiently hardened so as to permit the hollow article surrounding the wire to be peeled or stripped therefrom. One disadvantage of the dipping process is the large number of dips and great amount of time sometimes required to build up the desired amount of material on the wire. Additionally, when the hollow article to be manufactured requires a wire core of small diameter, many materials are too viscous in a liquified state for the wire to be dipped therein without bending of the wire.

As with the above described prior art dipping processes, other prior art processes also have disadvantages. For instance, extrusion processes are not advantageously employed to obtain hollow products with a closed end defining a blind bore. Further, while prior art molding processes may be employed to obtain products with closed ends, these processes are generally not advantageously employed when the article is relatively long and slender. The reason for this is that the portion of the mold defining the hollow portion of the final product is often unstable and bends at the high pressures employed in the molding process.

The process and apparatus of the invention may be employed to produce hollow products from a wide variety of materials including materials which are too viscous in a liquid state to be used to produce hollow articles by prior art dipping processes. Additionally, the process and apparatus of the invention may be employed to obtain hollow products with one of the ends closed by a tip. Finally, the process and apparatus of the invention may be used to manufacture hollow bodies which are relatively long and slender.

SUMMARY OF THE INVENTION

The invention provides a process of manufacturing a hollow article using a mold having an inside wall defining an elongate mold cavity extending between opposed ends; having a core longitudinally extending in said mold cavity; and having a plug contained in said mold cavity disposed about the core in surrounding relation thereto, said plug being disposed for sliding contact with said core and said inside wall and defining an annular space between the core and inside wall; which process comprises the steps of positioning said plug along the core at a predetermined distance from a first end of the mold cavity; introducing a molding material into said annular space at a location between the plug and first end of the mold cavity, and under a pressure sufficient to move the plug longitudinally along said core with the molding material flowing into said annular space in contact with the plug to

drive same toward the second and opposite end of the mold cavity until the plug reaches a preset terminal position, said plug maintaining and stabilizing the position of the core with respect to said inside wall to mold a hollow article of length corresponding to the distance between said terminal position and the first end of the mold cavity, and with thickness stabilized by the action of the plug; and stripping the resulting hollow article from the mold cavity and core.

The foregoing process can be practised according to a further embodiment of the invention using a core having a free end positioned within the mold cavity a preset distance from said second end of the mold cavity, which distance is sufficient to allow said plug to reach a terminal position within the mold cavity off said core and with a given space between the plug and the free end of the core, which space extends transversely across said annular space, which process further comprises the steps of introducing the molding material under pressure until the plug reaches the terminal position off the free end of the core and then continuing to introduce molding material into said annular space until molding material fills said transversely extending space between the plug and free end of the core to form a hollow article with a blind bore.

The invention further provides an apparatus for manufacturing a hollow molded article, which comprises a mold having an inside wall defining an elongage mold cavity extending between a first end and a second end opposed to said first end; a core extending longitudinally in said mold cavity toward said second end thereof; a plug contained in said mold cavity disposed about said core in surrounding relation thereto, said plug being disposed for sliding contact with the core and said inside wall and defining an annular space between the core and inside wall; and means defining an inlet in said mold cavity to accommodate introducing a molding material under pressure into said annular space at a location between the plug and first end of the mold cavity to move the plug longitudinally along said core with the molding material flowing into said annular space in contact with the plug to drive same toward the second and opposite end of the mold cavity until the plug reaches a preset terminal position, to thereby mold a hollow article of length corresponding to the distance between said terminal position and the first end of the mold cavity and with a thickness determined by the spacing between the core and inside wall, said plug being operable to maintain a predetermined thickness dimension of the molded hollow article.

For manufacturing a hollow article with a blind bore, the aforementioned apparatus is so constructed such said core has a free end positioned within the mold cavity a preset distance from said second end of the mold cavity, which distance is sufficient to allow the plug to reach a terminal position within the mold cavity off said core and with a given space between the plug and the free end of the core, which space extends transversely across said annular space to receive said molding material to form a hollow article with a blind bore, the molding material in said space between the plug and free end of the core forming a closed end portion of the hollow article.

During the molding process the mold cavity is desirably maintained at a suitable temperature so that shortly after the plug reaches the distal end of the cavity the material injected into the cavity will be cured or hardened. After the molded material is sufficiently cured or hardened the mold is opened and the hollow article is stripped or peeled from the wire core.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the mold employed according to one embodiment of the invention.

Fig. 2 shows a cross section of Fig. 1 along line 2-2.

Fig. 3 shows the mold employed in another embodiment of the invention.

Fig. 4 shows the arrangement of the follower and wires during one stage of an embodiment of the invention.

Fig. 5 shows the arrangement of the follower and wires at the completion of one embodiment of the invention.

Fig. 6 shows the arrangement of the follower and wires at yet another stage of one embodiment of the invention.

Fig. 7 shows a cross section of Fig. 6 along line 7-7.

Fig. 8 shows the relationship of follower to the second wire in one embodiment of the invention.

Fig. 9 shows the relationship of the follower to the second wire in another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Fig. 1 there is shown in cross section mold 10 with core wire 11 and follower plug 12 provided therein. As shown in Fig. 1, wire 11 is hung from a source 17, enters at a first or proximal end 15 of mold 10 and terminates at 13 close to the opposite, second or distal end 14 of mold 10. However, it is to be understood that any suitable means for providing the wire in the mold cavity may be employed in the invention. For instance, the wire 11 may be embedded into or adhesively attached to the end 14 of mold 10.

As shown in Fig. 1, plug 12 fits snugly into annular space 16 in close abutment with core

wire 11 and the inside of mold 10. As is perhaps best seen from Fig. 2, the plug 12 fills the entire cross section between the inside wall of mold 10 and core wire 11. The plug 12 fits into annular space 16 so that it will not drop to the end 14 of mold 10 due to its own weight. Additionally, the plug 12 is fitted into annular space 16 so that in use substantially no material injected into the mold will flow into the spaces between the plug 12 and the inside wall of mold 10 and core wire 11. In practice, the maximum size of the spaces may vary slightly depending on the material molded, but clearances less than about .005 inches are preferred with clearances less than about .001 inches being most preferred.

At the start of the process the plug 12 is located at a predetermined distance from end 15 of the mold 10. While some of the advantages of the present invention may be obtained when the plug 12 is located elsewhere, it is preferred that the end of the follower 12 which faces mold end 14 be located somewhere along the first 20% of the distance between the first end 15 and second end 14 of the mold 10 and most preferably along the first 1% of this distance from end 15.

With the core wire 11 and plug 12 suitably arranged in mold 10, material to be molded, e.g., catalyzed silicone rubber, is injected into annular space 16 by suitable means (not shown) at a location between plug 12 and the first end 15 of mold 10, preferably at about 2500 to 40,000 psig and most preferably at about 4000 - 10,000 psig. Suitable means for injecting the silicone rubber into the mold are well known to those skilled in the art. For example, reciprocating screw injection molding machines can be equipped with rubber injection units and employed in the present invention.

Preferably, the catalyzed silicone rubber injected has been freshened, e.g., on a two roll mill, to eliminate any structuring of the silicone rubber that may have occurred during storage and to soften the composition sufficiently for the molding process. During the freshening operation suitable cross-linking agents or catalysts may be admixed with the silicone rubber. Both in the premixing device and molding machine, the temperature of the catalyzed silicone rubber must be kept sufficiently low so as to prevent the activation of the catalyst but at the same time sufficiently warm so that the material will flow easily when injected into the mold. The temperatures that should be maintained, of course, will vary with the silicone rubber material being molded and the specific catalyst system employed, but for known peroxide catalysts the temperatures of the silicone rubber injected into annular space 16 is preferably maintained at about 80°F. to 130°F.

It is to be understood that any type of catalyst may be employed with the silicone rubber of the present invention, but the preferred catalysts ae peroxide catalysts, with the most preferred being di(2,4-dichlorobenzoyl) peroxide, dibenzoyl peroxide, dicumyl peroxide, 2,5-dimethyl-2,5-di (t-butylperoxy)-hexane or mixtures thereof. Similarly, the amount of cross linking agent or catalyst employed may be widely varied with the most preferred amounts being .5-1.5 parts by weight di(2,4-dichlorobenzoyl) peroxide, .5 to 1.0 parts by weight dibenzoyl peroxide, .5 to 1.6 parts by weight dicumyl peroxide, and .4 to 1.5 parts by weight 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, all parts per 100 parts by weight silicone rubber.

The catalyzed silicone rubber injected into the mold cavity flows through annular space 16 pushing plug 12 ahead of it until the end of the follower 12 facing end 14 of mold 10 reaches the end 14 of mold 10. At this point, in the embodiment of Fig. 1, the plug 12 is still partially on core wire 11. As a result a hollow article that is open at both ends is molded about core wire 11. As the plug 12 moves longitudinally through the mold 10, it maintains and stabilizes the wire at the desired distance from the inside wall of mold 10. Small air vents are located along the length of mold 10 so as to relieve air pressure that would otherwise build up as the silicone rubber and follower 12 move toward the end 14 of mold 10.

The temperature of the mold 10 is preferably maintained during processing in a range which will activate the catalyst system in the silicone rubber. The temperature of mold 10 and rate of flow in annular space 16, of course, must be regulated so that the silicone rubber does not cure to the extent that precludes complete flow of silicone rubber into annular space 16. The temperature is preferably maintained, however, so as to minimize the cure time after complete injection of silicone rubber into mold 10. The mold 10 may be maintained at the desired temperature in a variety of ways. For example, one suitable method comprises supplying heat from electric heating elements located in the walls of mold 10. Another suitable method for maintaining the mold at a suitable temperature comprises circulating a hot fluid, e.g., hot oil, through channels in the walls of the mold. While precise temperatures will vary with the particular silicone rubber composition and process employed, suitable mold temperatures for di(2,4-dichlorobenzoyl) peroxide or dibenzoyl peroxide are about 240-270°F, for dicumyl peroxide about 310-360°F., for 2,5-dimethyl-2,4-di(t-butylperoxy)hexane about 330-360°F. and for mixtures of the

above catalysts the highest temperature of any constituent of the mixture.

Once the silicone rubber is sufficiently cured, the mold 10 is opened and the silicone rubber hose-like article may be manually peeled or stripped from the core wire 11. Before stripping the silicone rubber hollow article from the wire, the hollow article and core wire 11 may be removed from the mold 10 as a unit. In such a case the mold 10, of course, should be designed so that the core wire 11 can be easily removed and reinstalled each time an article is molded. It may also be desirable to soak the coated wire in a suitable organic solvent, e.g. toluene, in order to swell the hollow article before the article is stripped from the wire. In the swelled state the hollow article then may be more easily stripped from the wire. After the article is stripped from the wire the organic solvent is then evaporated and the silicone rubber article will then shrink back to normal size.

Further regarding the core wire 11 which is employed in the present invention, it is preferred that the wire be solid so as to minimize bending which may occur during the injection molding process. However, the core wire may be hollow as represented by dotted line 18 in Fig. 2. The core wire 11 may be made from any material which is capable of withstanding the side stresses which may occur during the molding process of the present invention. Preferably, the core wire is hardened steel which has been polished and coated with a release agent so as to enhance the sliding of the follower through annular passageway 16 and to aid in the removal of the hollow article produced by the injection molding process. The choice of release agents will depend on the particular composition being molded, but with silicone rubber the preferred release agents are fluorocarbon polymers applied as dispersions of fine particle in a suitable vehicle. The most preferred release agent for silicone rubber is Vydax (Registered Trade Mark), a dispersion of a telomer of tetrafluoroethylene in a vehicle of trichlorotrifluoroethylene. The preferred release agents employed are fluorocarbons such as Vydax. As shown in Fig. 2 the mold 10 and core wire 11 are cylindrical. However, it is to be understood that other configurations of each are contemplated as within the scope of the invention.

The plug 12 may be made from any material which is capable of sliding through annular passageway 16 as described above. The preferred materials that may be employed are case hardened steel coated with the same release agent coated on core wire 11, or a plastic, e.g., poly(tetrafluoroethylene) which is lubricated by the release agent coated on core wire 11. It is to be understood however, that followers made from other material may be employed within the scope of the present invention.

Referring now to Fig. 3 there is shown an apparatus for producing a closed ended hollow article according to the present invention. More specifically, and for purposes of illustration, there is shown an apparatus for producing a non retention urinary catheter according to the present invention.

Urinary catheters, as is well know to physicians, are used in the treatment of individuals who have lost control of their urinary functions. One generally accepted medical practice involves inserting a tube or catheter up the urinary passage until the remote or distal end of the catheter remains outside the body. Often the most proximal end of the catheter is in the shape of a funnel. The funnel is in communication with a path or drainage lumen that is provided along the longitudinal axis of the catheter. The distal end of the catheter contains a hole in communication with the drainage lumen such that in use the bladder may drain through the hole into the drainage lumen and out through the funnel into a suitable receptacle. While the invention is described with respect to urinary catheters, it is to be understood that other types of catheters, e.g. tracheal catheters and venous catheters operage on similar principles and may be manufactured according to the present invention.

As shown in Fig. 3 there is provided mold 30 with first core wire 31 and second core wire 41 longitudinally aligned with the first core wire 31 so that the use plug 32 may slide from first core wire 31 to second core wire 41. Core wire 31 is attached to suitable source which, as shown in Fig. 3, may be the end 35 of mold 30 corresponding to the proximal end of the catheter product. First core wire 31 terminates at a free end 33 spaced from the free end 43 of second core wire 41. The plug 32 is fitted snugly into annular space 36 closely abutted to core wire 31 and the inside of mold 30 as described before in the description of Fig. 1. It will be noted that toward the end 35 of mold 30 wire 31 widens so that the proximal end of the catheter produced by the present invention is funnel shaped. It will further be noted by those skilled in the art that the proportions shown in Fig. 3 are not the proportions which would normally be employed in the manufacture of urinary catheters. That is, a typical urinary catheter may be about 16 inches long and about 0.24 inches in diameter. These values are not reflected in Fig. 3 however, for convenience of illustration.

As shown in Fig. 3, at the start of the process the plug 32 is preferably located in annular space 36, a short distance from the

widened portions of core wire 31. Preferably, the end of the plug 32 facing mold end 35 is located somewhere along the first 20% of the distance between the end 35 and the opposite end 34 of the hold 30 and most preferably along the first 1% of this distance. With the core wire 31 and plug 32 suitably arranged in mold 30 the material to be molded, which again for purposes of illustration is catalyzed silicone rubber, is injected under pressure by suitable means (not shown) into the proximal end of mold 30. The catalyzed silicone rubber composition may be prepared in the same manner and from the same materials as noted above in the description of the embodiment shown in Fig. 1. Additionally, the silicone rubber is suitably injected into annular space 36 at the same temperatures and pressures described above in connection with the description of Fig. 1.

The catalyzed silicone rubber which has been injected into the mold cavity flows through annular space 36 and pushes plug 32 ahead of it. Eventually the mold end 35 facing end of plug 32 reaches the free end 33 of core-wire 31. At this point the plug 32 continues to slide along the core wire 31 in response to the pressure of injected silicone rubber. Before the plug 32 disengages completely from the first core wire 31 it engages second core wire 41 as shown in Fig. 4. The plug 32 then continues along annular passageway 36 until the end of the plug 32 facing end 34 reaches such 34 of mold 30. At this point the arrangement of first core wire 31, second core wire 41, and plug 32 in mold 30 is as shown in Fig. 5.

It will be observed upon reference to Figs. 4 and 5 that once plug 32 disengages from first core wire 31 the silicone rubber injected into the mold 30 may spread throughout the cross section defined by the inner wall of mold 30. As a result a solid tip or closed end portion is provided for the catheter produced. As shown in Fig. 3-5 the surface of the plug 32 facing mold end 35 and the end surface 43 of core wire 41 are concave. Additionally, the plug 32 and second core wire 41 are designed so that the transition from the concave surface of the plug 32 to the concave surface 43 of second core wire 41 is continuous, as shown in Fig. 5. As a result of the above two factors, a desirable smooth rounded closed end portion for the catheter for better insertion is provided by the present invention.

It will be observed upon reference to Figs. 3-5 that the free end 33 of the first core wire 31 is preferably rounded so that the catheter will have a continuous smooth inside surface at its distal end. It is to be understood, however, that the shape of the end 33 of the first core wire 31 may be varied within the scope of the present invention.

After the plug 32 reaches the end 34 of mold 30, the molded catheter is cured and stripped from the first core wire 31 as described before in connection with the description of Fig. 1. Once the catheter is removed from first core wire 31, at least one hole is provided through the closed end ortip is provided through the closed end or tip of the catheter which communicates with the drainage lumen defined by the hollow portion of the catheter. The hole may be provided in a manner well known in the art such as mechanical punching or burning.

It will be appreciated by those skilled in the art that the first core wire 31 and plug 32 may be twisted in mold 30 as a result of side stresses caused by the injection of silicone rubber under high pressure. It will further be appreciated that when the first and second core wires are cylindrical and concentric with the inside walls of mold 30, then the twisting will not substantially affect the transfer of plug 32 from first core wire 31 to second core wire 41 since, even after being twisted, the cylindrical first core wire 31 will still be concentrically disposed and therefore aligned with second core wire 41 within the mold 30. However, when the first core wire 31 and second core wire 41 are not cylindrical and concentric with the inside walls of the old mold cavity, a severe problem may be created if first core wire 31 is twisted in the mold as a result of the fluid pressure in the mold cavity. The problem created is that when core wire 31 is twisted then plug 32 is also twisted and is therefore no longer aligned with second core wire 41. As a result, unless the plug 32 and second core wire 41 are especially designed as hereinafter described, the plug 32 will not slide from the first core wire 31 onto second core wire 41.

Referring now to Figs. 6 and 7 there is shown a longitudinal side view and cross sectional view of the arrangement of first core wire 31, second core wire 41, and plug 32 in mold 30 at the instant the plug 32 begins to engage second core wire 41. As seen from Figs. 6 and 7, the inside wall of plug 32 tapers gradually outwardly at least at the distal portion of the follower so that at the point where plug 32 begins to engage second core wire 41 the cross sectional area defined by the inner wall of the inner wall of the end 37 of plug 32 is larger than the cross sectional area defined by the end 43 of the second core wire 41. As a result, even if the plug 32 and second core wire 41 are somewhat out of alignment they will still engage with each other and align themselves gradually as the plug travels toward the end 34 of mold 30.

It will be recalled that it was earlier noted that substantial alignment problems do not occur when the core wire is cylindrical and concentric with the mold wall as is shown in

Figs. 6 and 7. However, even when the core wire appears cylindrical and concentric with the mold as shown in Figs. 6 and 7, it is still preferred that the plug and second wire be designed as shown in Figs. 6 and 7 since the core wires may not be perfectly concentric or cylindrical or the core wires may be somewhat distorted by the twisting described before.

As noted above, the cross sectional area defined by the inner wall of the end 37 of plug 32 is preferably larger than the area defined by the end 43 of the second core wire 41. As used herein, when it is said that one cross sectional area is greater than another, it is meant that the smaller cross sectional area may be superimposed entirely within the larger cross sectional area as is shown in Fig. 7.

Referring now to Fig. 8 and 9 there are illustrated two other examples where the cross sectional area defined by the inner wall of the end of a plug is greater than the cross section area defined by the free end of the second core wire. As in Fig. 7, the views shown in Figs. 8 and 9 are taken along a line through the proximal end of the second core wire. In Fig. 8 there is shown mold 60 in which there is a non-concentric cylindrical second core wire 62 aligned with a first core wire not shown and plug 61. As shown in Fig. 8, the cross sectional area defined by the free end of second core wire 62 does not cross or touch the cross sectional area defined by the inner wall of the plug 61 at its confronting end. Therefore, as defined above, the cross sectional area defined by the free end of the second core wire 62 is smaller than the cross sectional area defined by the inner wall of plug 61 at its confronting end.

In Fig. 9 there is shown mold 70 in which there is a core wire 72 with a square cross section and plug 71. Again, as shown, the cross sectional area defined by the second core wire 72 is smaller than the cross sectional area defined by the inner walls of the plug at its confronting end.

It should be recognized that the differences in cross sectional area as shown in Figs. 7 and 9 are exaggerated for the purposes of illustration. In practice, in appropriate circumstances the cross sectional areas may only differ from each other slightly, e.g., on the order of a few thousandths of a square inch.

While the preferred embodiments described above have employed catalyzed silicone rubber, it is to be understood that any material that may be injection molded may be employed in the apparatus and process of the present invention. These materials may be thermoplastic polymers, thermosetting polymers or other moldable materials. A particularly desirable class of thermosetting polymers are heat curable elastomers. Examples of thermoplastic polymers that may be employed in the present invention include polyethylene, polypropylene, vinyl polymers and copolymers, polystyrene, nylon, acrylonitrile butadiene styrene and thermoplastic polyesters. Examples of thermosetting polymers, in addition to silicone rubbers, include natural rubber, other synthetic rubbers, polyurethane, thermosetting polyesters and expoxies. Examples of other moldable materials include, but are not limited to wax, asphalt, plaster, concrete, glass and metals. It is to be understood that the properties of the above materials are well known in the art and it is within the purview of those skilled in the art to cause said materials to flow and set in a mold cavity as required in my process.

It is also to be understood that a plurality of hollow articles, in addition to the ones described above, may be made by the process and apparatus of my invention. Other medical devices that may be made include trocar catheters, endotracheal tubes, tracheostomy tubes, and drainage tubes with specially shaped ends. Other non-medical devices that may be made include tubular connectors for recirculating the exhaust gases of internal combustion engines, tubular connectors for emergency oxygen supply systems on commercial aircraft, hoses with specially shaped ends for use in dishwashing machines and tubular connectors for circulating fluids in office duplicating machines.

The invention may also be employed to produce articles much larger or smaller than those described above. Examples of larger articles include vacuum cleaner hose and sewer pipe sections. It is therefore to be understood that the core wires employed according to the present invention may have cross sectional areas on the order of anywhere between a few thousandths of a square inch to several square feet or more.

It is further to be understood that articles that have nonlinear longitudinal center lines may be produced by the process and apparatus of the present invention. In this embodiment of the invention a curved core wire is provided in a mold with a curved inside wall.

Further, it is to be understood that a second core wire is not required in order to obtain hollow articles with a solid tip. Rather, the mold cavity may be designed so that the plug slides off the first core wire and then slides by itself the rest of the way to the end of the mold cavity. It is apparent, however, that in this embodiment material being molded will flow into the hole of the follower to provide a "pigtail". As a result, a smooth tip will not be directly obtained. However, in this embodiment a smooth tip may be subsequently provided, e.g., by clipping the pigtail and polishing the tip.

It is additionally to be understood that molds and core wires of varying cross sectional area may be employed according to the present invention. For example, the mold cavity may be enlarged along a portion of the longitudinal distance traversed by the plug in the mold cavity. In this embodiment, the length of the enlarged portion of the mold is smaller than the longitudinal length of the plug so that in operation the plug will span the enlarged portion of the mold cavity and always maintain contact in close abutment with a portion of the inside wall of the mold.

Finally, it is to be understood that articles with more than one hollow channel may be produced according to the present invention. For example, two core wires may be positioned in the mold in parallel arrangement and the plug provided with two holes in order to obtain a hollow article with two parallel channels.

WHAT WE CLAIM IS:

1. A process of manufacturing a hollow article using a mold having an inside wall defining an elongate mold cavity extending between opposed ends; having a core longitudinally extending in said mold cavity; and having a plug contained in said mold cavity disposed about the core in surrounding relation thereto, said plug being disposed for sliding contact with said core and said inside wall and defining an annular space between the core and inside wall; which process comprises the steps of positioning said plug along the core at a predetermined distance from a first end of the mold cavity; introducing a molding material into said annular space at a location between the plug and first end of the mold cavity, and under a pressure sufficient to move the plug longitudinally along said core with the molding material flowing into said annular space in contact with the plug to drive same toward the second and opposite end of the mold cavity until the plug reaches a present terminal position, said plug maintaining and stabilizing the position of the core with respect to said inside wall to mold a hollow article of length corresponding to the distance between said terminal position and the first end of the mold cavity, and with thickness stabilized by the action of the plug; and stripping the resulting hollow article from the mold cavity and core.

2. A process of manufacturing a hollow article according to claim 1 using a core having a free end positioned within the mold cavity a preset distance from said second end of the mold cavity, which distance is sufficient to allow said plug to reach a terminal position within the mold cavity off said core and with a given space between the plug and the free end of the core, which space extends transversely across said annular space, which process further comprises the steps of introducing the molding material under pressure until the plug reaches the terminal position off the free end of the core and then continuing to introduce molding material into said annular space until molding material fills said transversely extending space between the plug and free end of the core to form a hollow article with a blind bore.

3. A process of claim 1 or 2 wherein the molding material comprises catalyzed silicone rubber.

4. A process according to claim 1, 2 or 3 which further comprises maintaining said mold cavity at a temerature sufficient to partially cure said material as it distally displaces the plug in the mold.

5. A process according to any one of the preceding claims wherein said plug is initially located within a distance from the first end of the mold cavity equal to 20 percent of the mold cavity length between said first and second ends thereof.

6. A process according to any one of the preceding claims wherein the hollow article is expanded by soaking it in an organic solvent before it is stripped from the core.

7. An apparatus for manufacturing a hollow molded article, which comprises a mold having an inside wall defining an elongate mold cavity extending between a first end and a second end opposed to said first end; a core extending longitudinally in said mold cavity toward said second end thereof; a plug contained in said mold cavity disposed about said core in surrounding relation thereto, said plug being disposed for sliding contact with the core and said inside wall and defining an annular space between the core and inside wall; and means defining and inlet in said mold cavity to accommodate introducing a molding material under pressure into said annular space at a location between the plug and first end of the mold cavity to move the plug longitudinally along said core with the molding material flowing into said annular space in contact with the plug to drive same toward the second and opposite end of the mold cavity until the plug reaches a preset terminal position, to thereby mold a hollow article of length corresponding to the distance between said terminal position and the first end of the mold cavity and with a thickness determined by the spacing between the core and inside wall, said plug being operable to maintain a predetermined spacing between the core and inside wall to stabilize the thickness dimension of the molded hollow article.

8. An apparatus acording to claim 7 wherein said core has a free end positioned within the mold cavity a preset distance from said second end of the mold cavity, which distance is sufficient to allow the plug to

reach a terminal position within the mold cavity off said core and with a given space between the plug and the free end of the core, which space extends transversely across said annular space to receive said molding material to form a hollow article with a blind bore, the molding material in said space between the plug and free end of the core forming a closed end portion of the hollow article.

9. An apparatus according to claim 8 wherein said plug has a concave surface that faces toward the free end of the core when the plug is in said terminal position, to form a corresponding convex surface on the closed end portion of the hollow article.

10. Apparatus according to claim 8 wherein said plug has a longitudinally extending passage through which said core extends in sliding contact with the plug, and including a second core extending from the second end of the mold cavity and positioned to extend through said passage of the plug when same is in said terminal position, said second core having a surface spaced from and facing the free end of the core extending toward said second end of the mold cavity, said surface of the second core being operable to form a corresponding surface on operable to form a corresponding surface on the closed end portion of the hollow article.

11. Apparatus according to claim 10 wherein said surface of the second core is concave for forming a corresponding convex surface on the closed end portion of the hollow article.

12. Apparatus according to claim 10 wherein the passage of said plug is tapered outwardly toward said second core to facilitate the extension thereof through said passage.

13. Apparatus according to claim 8 wherein said inside wall of the mold cavity is generally cylindrical and said core is cylindrical and generally concentric therewith.

14. Apparatus according to claim 8 wherein said inside wall of the mold cavity is generally cylindrical and said core is cylindrical and positioned eccentrically in relation to said inside wall.

15. Apparatus according to claim 8 wherein said inside wall of the mold cavity is generally cylindrical and said core is prismatic.

16. A process of manufacturing a hollow article substantially as hereinbefore described.

17. Apparatus for manufacturing a hollow article substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1524704 COMPLETE SPECIFICATION

2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

FIG. 1

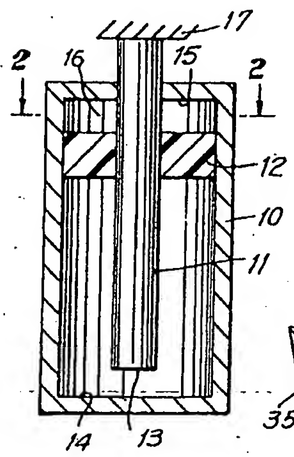


FIG. 2

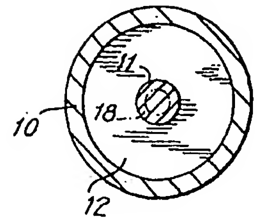


FIG. 3

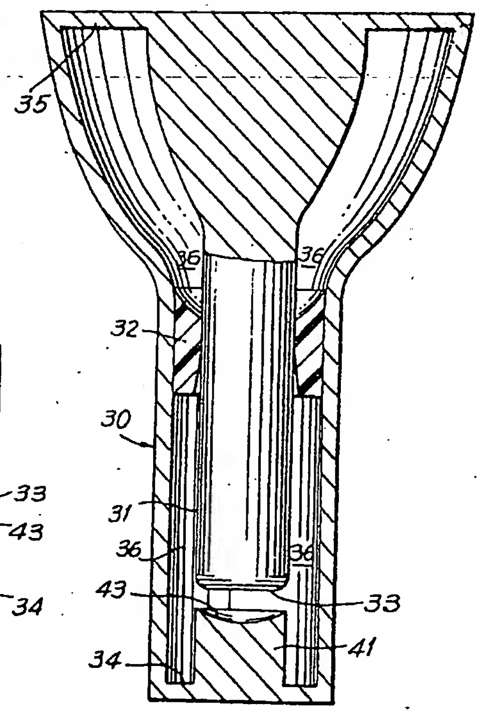
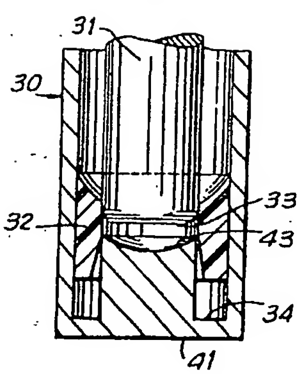


FIG. 4



1524704 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG.5

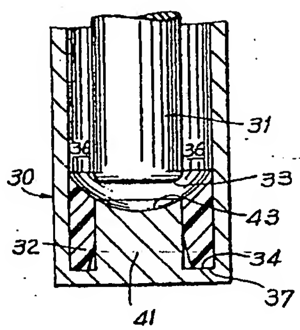


FIG.6

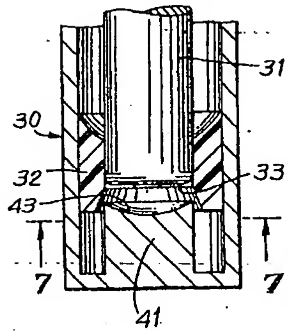


FIG.7

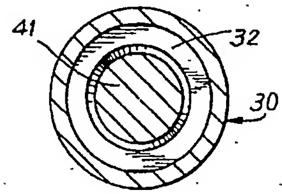


FIG.8

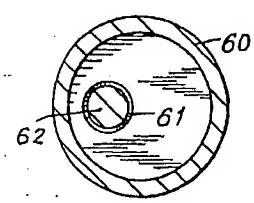


FIG.9